Review of ET Representation in ESPAM2.0 and How to Represent ET in ESPAM2.X

Presented by Mike McVay

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How we represent ET in ESPAM2.0

$$\mathbf{ET = [(ADJ_{spr})(Area)(1\text{-}RED_{spr})(SPR) + (ADJ_{grav})(Area)(1\text{-}RED_{grav})(1\text{-}SPR)]*ET_{trad}}$$

where:

- ET = evapotranspiration volume on an individual irrigated parcel
- $ADJ_{sp\,r}$ = ET adjustment factor for sprinklers
- Area = area of parcel
- RED_{spr} = reduction for non-irrigated inclusions, sprinklers
- SPR = sprinkler fraction for entity
- ADJ_{grav} = ET adjustment factor for sprinklers
- RED_{grav} = reduction for non-irrigated inclusions, gravity
- ET_{trad} = depth of ET on irrigated lands calculated by traditional methods

ADJ_{spr} and ADJ_{grav} include a global adjustment for high ET adjacent to irrigated lands

For the specifics of ET calculation refer to ESPAM 2 Design Document DDM-V2-11

General Process for Calculating ET in ESPAM2.0

1. Calculate Traditional ET for Irrigated Lands using county crop mix data and ET_{Idaho} values for Et_{act} (calculated with crop coefficient and reference ET).
2. Calculate "Actual ET" on Irrigated Lands using METRIC (pseudo-average 2000 and 2006).
3. Calculate a preliminary adjustment factor for each entity using METRIC/Traditional ET.
4. Calculated a global adjustment coefficient on a buffer area adjacent to Irrigated Lands.
5. Use the global coefficient to "correct" the preliminary adjustment and obtain the final ET adjustment factor for each entity ($ADJ_{sp\ r}$ and ADJ_{grav}).
6. Calculate ET volume for each entity.

$$\mathbf{ET = [(ADJ_{spr})(Area)(1\text{-}RED_{spr})(SPR) + (ADJ_{grav})(Area)(1\text{-}RED_{grav})(1\text{-}SPR)]*ET_{trad}}$$

Preliminary ET Adjustment Factors

The **preliminary by-entity adjustment factors** compensate for the following potential differences between METRIC ET and Traditional ET:

1. Differences in crop vigor due to chronic water stress, poor soil, insects, or disease.
2. Imprecision in underlying data.
    a. Entity has higher/lower-consumptive crops than the county average.
    b. Entity experiences higher/lower ET than at county weather station.
3. Low-intensity management.
4. Imprecision in traditional calculations and coefficients.
5. Changes in conditions from when traditional coefficients were developed
    a. More frequent irrigation.
    b. More dense planting.
    c. Increased vegetative yield.
    d. Longer growing season.

Global ET Adjustment Coefficients

The **global adjustment coefficient** compensates for the following potential differences:

1. Imprecision in underlying data.
    a. GIS and RED overstate/understate irrigated area.
2. Effects on or from non-irrigated lands adjacent to irrigated lands.
    a. Advection of heat into irrigated land.
    b. Overspray and runoff.

Issues or Concerns with ESPAM2.0 Methods

1. Acute water shortage in years other than 2000 and 2006 cannot be compensated for.
2. Acute water shortage in 2000 or 2006 that is not a chronic condition cannot be compensated for.
3. Calculating ET based on Irrigated Lands Maps (used RED factors to mitigate).
   a. Different data sources and methods for generating maps may not be comparable.
   b. Non-irrigated inclusions in the maps may not be accounted for properly.
4. Traditional ET calculation method imprecision (used adjustment factors, ad-hoc corrections).
   a. County crop mix data quality is a concern.
   b. County weather stations may not be representative of the entities.
   c. Non-irrigated lands adjacent to the irrigated lands.
5. Other consumptive use like small domestic, dairies, wetlands and industrial.
6. The calculation is complex which introduces compounding uncertainties.

Moving Forward to ESPAM2.X – METRIC

We want to use METRIC directly in the model.

1. Allows use of the best available data in the correct spatial and temporal context.
2. Removes the need for adjustment factors.
3. Removes the need for RED factors in ET calculation.
4. Eliminates reliance on county crop mix.
5. Uses more spatially appropriate weather station data.
6. Uses high-definition spatial definition of LANDSAT.
7. Captures edge effects outside of Irrigated Lands Maps (if using a buffer).

….but not all years in the model period will have METRIC coverage.

Next Step – Prioritize METRIC processing.

Potential METRIC Processing ESPA

1984 - too sparse
1985 - too sparse
1986 - yes (METRIC in Progress)
1987 - not as populated as 1986, but possible for METRIC
1988 - no April-May for METRIC on path 40
1989 - no Sept-Oct for METRIC on path 40, poor on path 39
1990 - possible METRIC on 40, not on 39
1991 - no
1992 - possible METRIC for 40 and 39
1993 - possible for METRIC, no April-May on 39
1994 - no May-June for METRIC path 40
1995 - no
1996 - yes (METRIC DONE)
1997 - yes, iffy METRIC for June-July on 39
1998 - no May for METRIC on 40 and 39
1999 - no for METRIC in spring
2000 - yes (METRIC DONE)
2001 - yes for METRIC on both paths
2002 - yes (METRIC DONE)
2003 - iffy for METRIC for both paths (path 40 DONE through August (no images after that))
2004 - yes for METRIC on both paths
2005 - iffy for METRIC
2006 - yes (METRIC DONE)
2007 - possible, but challenging for METRIC on path 40
2008 - yes (METRIC DONE)
2009 - yes (METRIC in Progress)
2010 - yes (METRIC in Progress)
2011 - yes for METRIC on both paths
2012 - If coverage is available, do we want this year – dry summer (SMOKE?)

Non-METRIC ET Years

1984 - too sparse
1985 - too sparse

1987 - not as populated as 1986, but possible for METRIC
1988 - no April-May for METRIC on path 40
1989 - no Sept-Oct for METRIC on path 40, poor on path 39
1990 - possible METRIC on 40, not on 39
1991 - no

1993 - possible for METRIC, no April-May on 39
1994 - no May-June for METRIC path 40
1995 - no

1997 - yes, iffy METRIC for June-July on 39
1998 - no May for METRIC on 40 and 39
1999 - no for METRIC in spring

2001 - yes for METRIC on both paths

2003 - iffy for METRIC for both paths (path 40 DONE through August (no images after that))
2004 - yes for METRIC on both paths
2005 - iffy for METRIC

2007 - possible, but challenging for METRIC on path 40

2011 - yes for METRIC on both paths
2012 - If coverage is available, do we want this year – dry summer (SMOKE?)

Non-METRIC ET Years

1980 – 1983 weather data?

1984 - too sparse
1985 - too sparse

1987 - not as populated as 1986, but possible for METRIC
1988 - no April-May for METRIC on path 40
1989 - no Sept-Oct for METRIC on path 40, poor on path 39
1990 - possible METRIC on 40, not on 39
1991 - no
1992 - possible METRIC for 40 and 39
1993 - possible for METRIC, no April-May on 39
1994 - no May-June for METRIC path 40
1995 - no

25 Years need a non-METRIC method of determining ET (temporary and permanent)

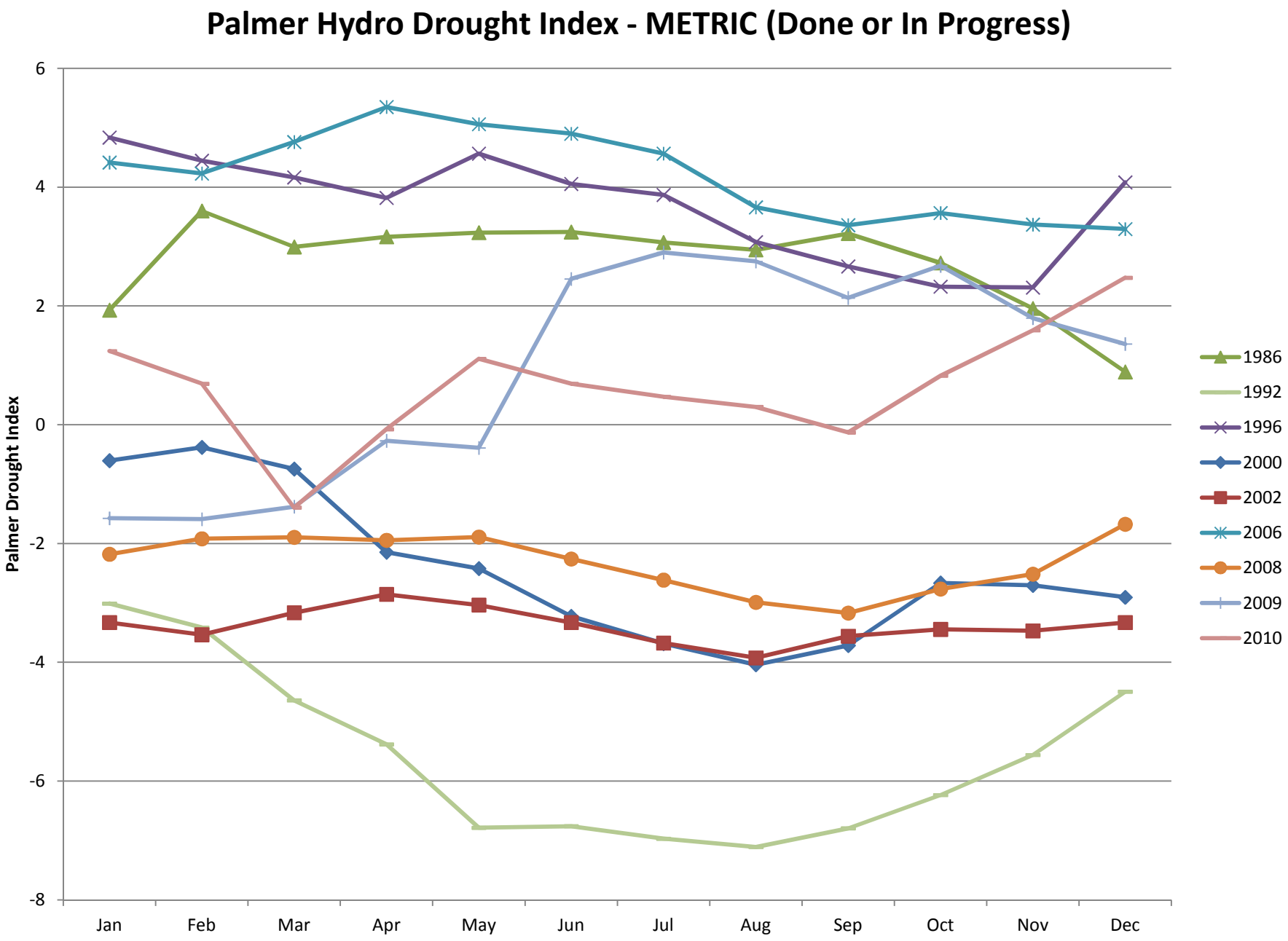
1997 - yes, iffy METRIC for June-July on 39
1998 - no May for METRIC on 40 and 39
1999 - no for METRIC in spring

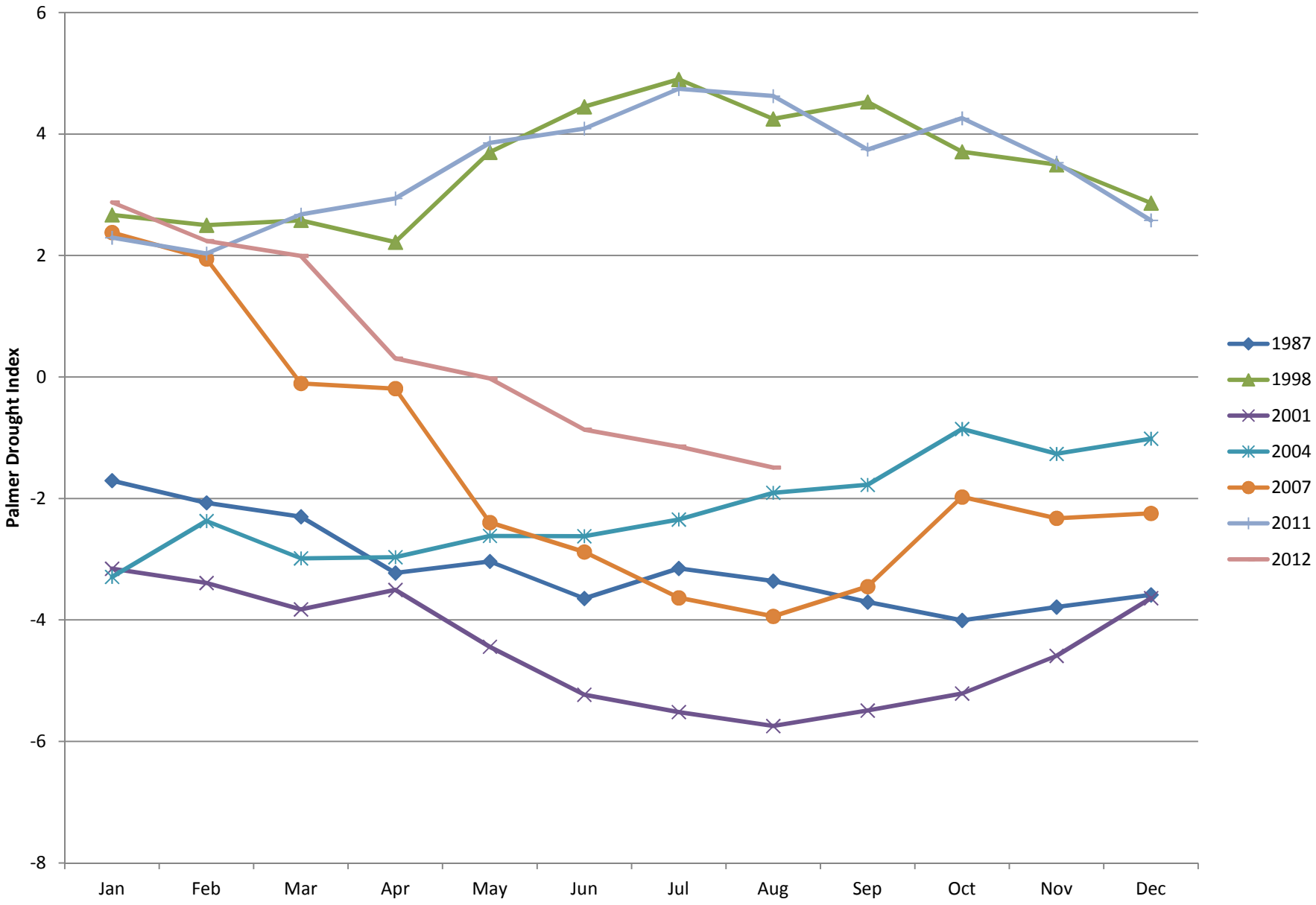
2001 - yes for METRIC on both paths

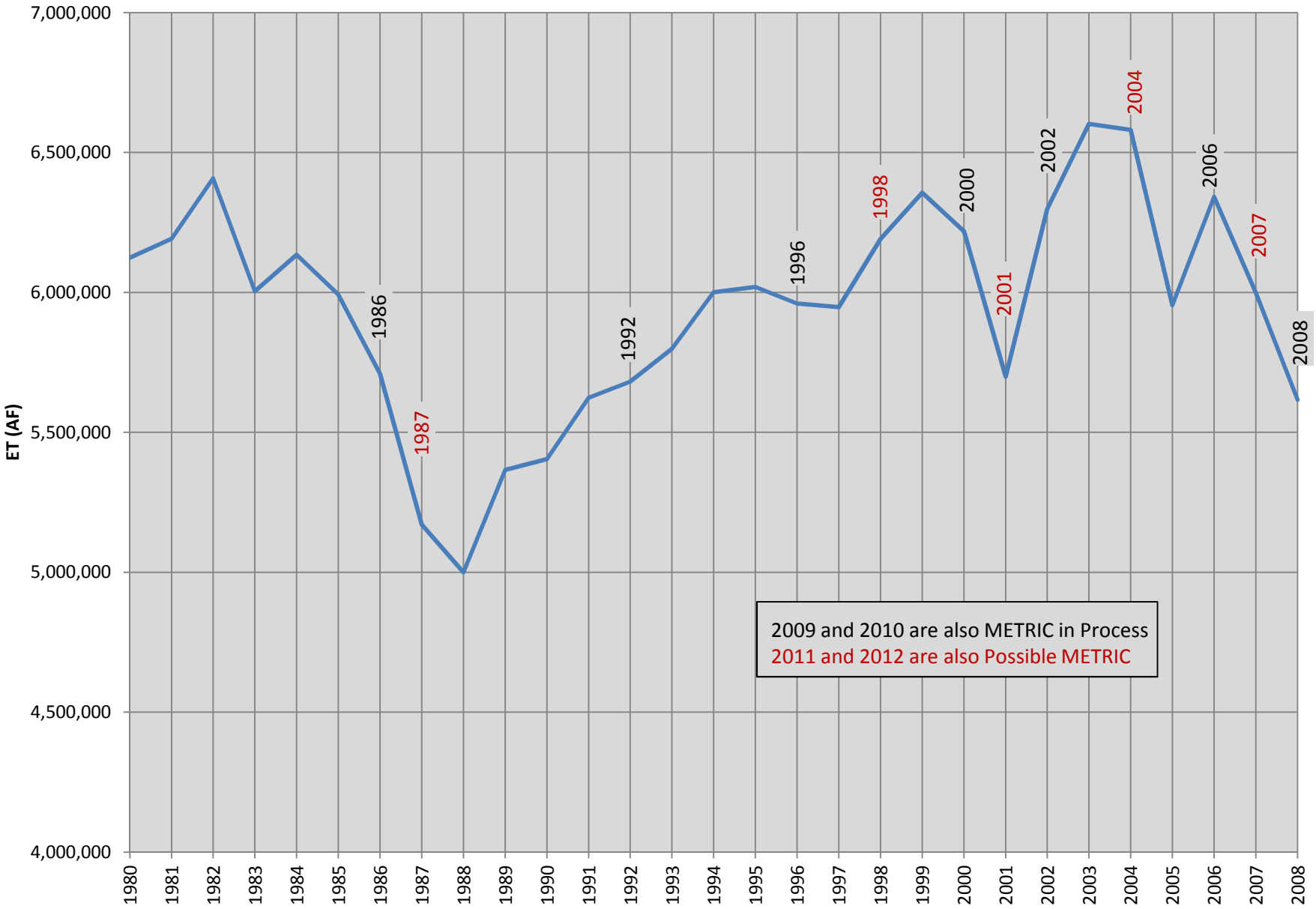
2003 - iffy for METRIC for both paths (path 40 DONE through August (no images after that))
2004 - yes for METRIC on both paths
2005 - iffy for METRIC

2007 - possible, but challenging for METRIC on path 40

2011 - yes for METRIC on both paths
2012 - If coverage is available, do we want this year – dry summer (SMOKE?)


Palmer Hydro Drought Index - METRIC (Done or In Progress)
Palmer Drought Index
6
4
2
0
-2
-4
-6
-8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1986
1992
1996
2000
2002
2006
2008
2009
2010


Palmer Hydro Drought Index - Possible METRIC
Palmer Drought Index
6
4
2
0
-2
-4
-6
-8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1987
1998
2001
2004
2007
2011
2012


Crop Mix - Total Crop ET (No Weather, No Adjustments)
ET (AF)
7,000,000
6,500,000
6,000,000
5,500,000
5,000,000
4,500,000
4,000,000
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
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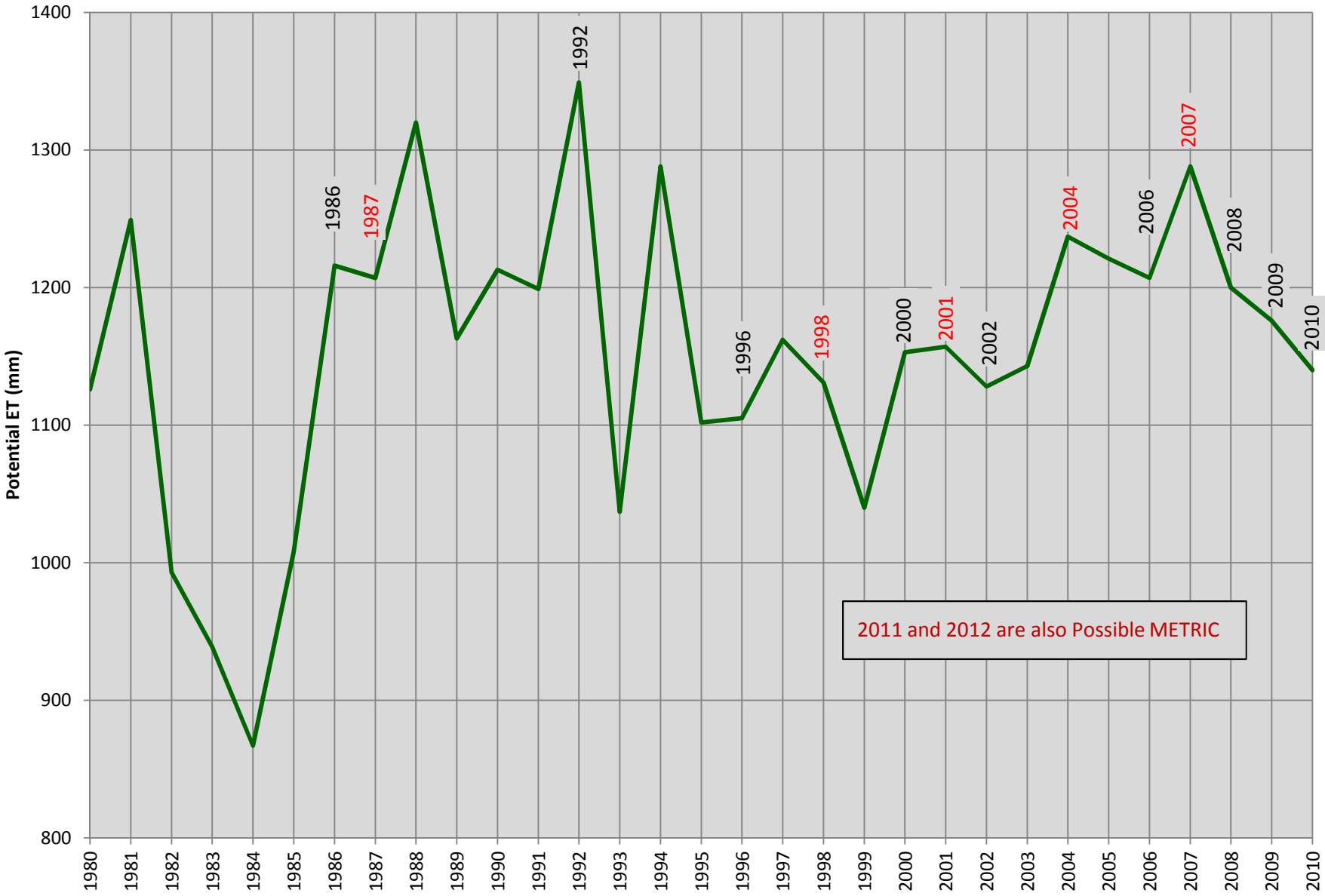
2007
2008
2009 and 2010 are also METRIC in Process
2011 and 2012 are also Possible METRIC


Potetial ET - Alfalfa at Aberdeen
Potential ET (mm)
1400
1300
1200
1100
1000
900
800
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
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1986
1987
1992
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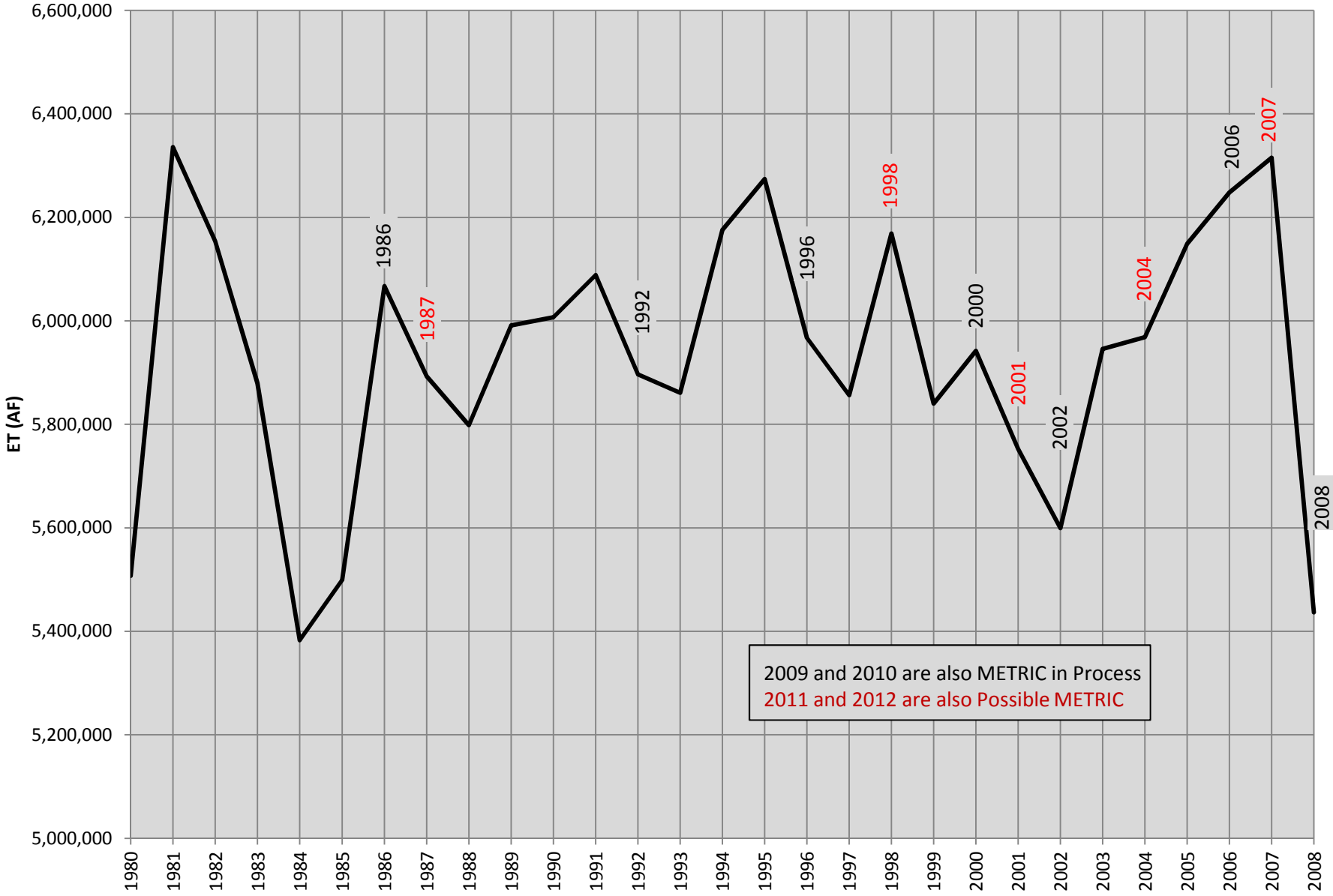
2001
2002
2004
2006
2007
2008
2009
2010
2011 and 2012 are also Possible METRIC

ESPAM2.0 - Total ET (with Adjustment Factors, No PEST)



Moving Forward to ESPAM2.X – ET Needs

What we NEED for the non-METRIC years

1. Need a method for 1980-1985 when METRIC is not available.
2. Need to Interpolate or extrapolate METRIC to non-METRIC years, or
3. Need to independently calculate or estimate ET for non-METRIC years.

What are the OPTIONS for the non-METRIC years?

1. Interpolate or Extrapolate METRIC data to non-METRIC years.
    a. Find correlation to some index (like NDVI).
    b. Mathematical interpolation (like a linear interpolation or average of METRIC).
    c. Similar-year substitution.
2. Independent calculation or estimation method.
    a. NDVI Method or other simplified proxy.
    b. Satellite-based method (MODIS, SEBAL).
    c. Traditional calculation methods.

End Part 1

Options for Representing ET in ESPAM2.X

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Brainstorming Options

This is not a presentation on the various options, how they work, or the benefits and drawbacks.

This is a list intended to generate ideas and discussion.

Satellite-based Options

1. Surface Energy Balance Algorithm for Land (SEBAL).
   a. Maybe an alternative for early 1980's due to less ground data requirements.
   b. Not sure of satellite coverage in 1980's.
2. Simplified Surface Energy Balance (SSEB).
3. METRIC Flat Model. Use as a filler until METRIC Mountain Model products are ready.
4. Apply METRIC to MODIS imagery.
   a. Lower resolution (1 km), but may be able to correlate with METRIC years.
   b. Daily images, may help with cloudiness.
   c. Satellite begins year 2000.
5. Advanced Very-High Resolution Radiometer (AVHRR).
   a. Lower resolution (1 km), but may be able to correlate with METRIC years.
   b. 14 Images per day
   c. Satellite begins year 1994.
6. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER).
   a. Cost is $50 per image.
   b. Daily images.
   c. Satellite begins year 1999.
7. Other satellites?

Other Options

1. ESPAM2.0 Method
2. Different application of the Kc * ETr method.
   a. METRIC-driven adjustment factors.
3. NDVI Method or other simplified proxy.
4. Interpolate or Extrapolate METRIC data to non-METRIC years.
   a. Find correlation to some index (like NDVI).
   b. Mathematical interpolation (like a linear interpolation or average of METRIC).
   c. Similar-year substitution.

Other Considerations

1. Winter (non-irrigation season) ET.
2. ET on non-irrigated land.
3. Method consistency vs. best estimate.
4. Use of partial MERTIC in years with incomplete imagery.
5. PEST adjustment of ET.
    a. PEST Adjustment of non-METRIC ET?
    b. PEST adjustment of METRIC ET?
6. Alternate crop-mix data source.

In closing…